Welcome

Presents

"Adding Hybrid And EV Service To Your Shop - Is This Your Year?"

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Thanks to our sponsor…

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What Will Be Covered:

- **Safety**
- **How HV systems works**
- **Testing HV batteries, for example, is a growing source of revenue as they near their useful service life and begin to rob vehicle owners of those high MPG numbers.**
- **Identifying isolation faults in the Motor/Generators is another ticket to a high revenue item.**
- **And more…**

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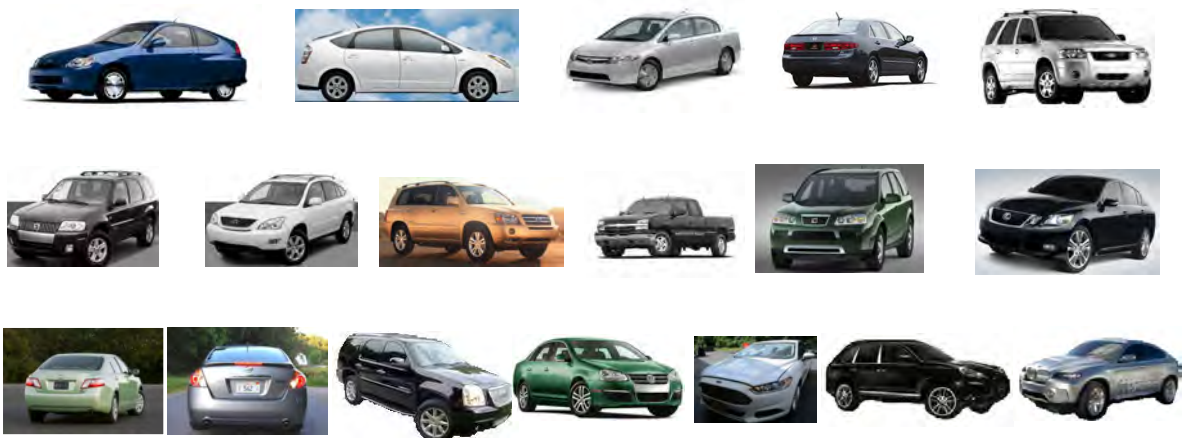
3

Hybrids

Vehicles On The Road



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4

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Electric

Vehicles On The Road

Nissan Leaf:

Dashboard	Drivers display
	

Tesla Model S:

Dashboard	Drivers display
	

BMW i3:

Dashboard	Drivers display
	

Chevy Bolt

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5

Hybrid - EV - The Difference

Hybrid electric vehicle (HEV/PHEV)

A hybrid vehicle is a vehicle with at least two different possibilities of propulsion.

Generally, this refers to the internal combustion engine as well as to the electrical drive motor. In other words, the vehicles can be driven conventional, running purely on the ICE or on both in means of a torque assist. Further developed hybrid concepts also allow a pure electric drive a lower speeds. Hybrid vehicles can also be equipped with a charging port (PHEV).

Pure electric vehicle (EV/EV-RE)

" ... is a vehicle designed for use in road traffic and driven solely by an electric motor whose drive energy is supplied solely by a battery installed in the vehicle "
An electric vehicle possesses one or more electric motors serving as drive units.

This kind of vehicle is driven purely by electrical energy, without the need for a combustion engine and the battery can only be charged externally. Some manufacturers define vehicles with a range extender also as EVs.

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Hybrid Safety

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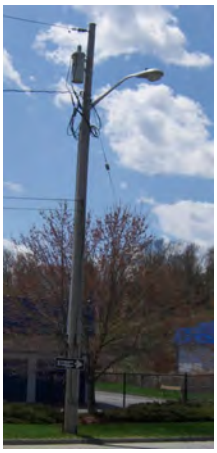
Everyday Utility Companies Work With High Voltage Without Anyone Being Injured



Know What to Do and Work Safe

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Hybrid Safety

Lethal Voltages and Current Capacity

Semi-standard Wire Colors

Low: < 30V, Red/Black 12V type

Intermediate: < 60V, Blue or Green

High: > 60V, Orange

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9

Hybrid Safety

- **Remove jewelry, watches, phones, etc**
- **Metal objects increase contact surface area**
- **Metal objects conduct high current and BURN**
- **Wear HV gloves near ANY open connections**
- **Test gloves for pinholes**
- **Cat III meters/scopes/leads**

Same Gear Used by Electricians and Utility Workers

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Hybrid Safety

High voltage orange cables run under the vehicle from the rear of the vehicle to the engine / MG components.

Voltage can be in these cables at anytime!

According to hybrid vehicle manufacturers a Hybrid must be "Powered Down" prior to starting any extrication or towing attempts.

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Hybrid Safety

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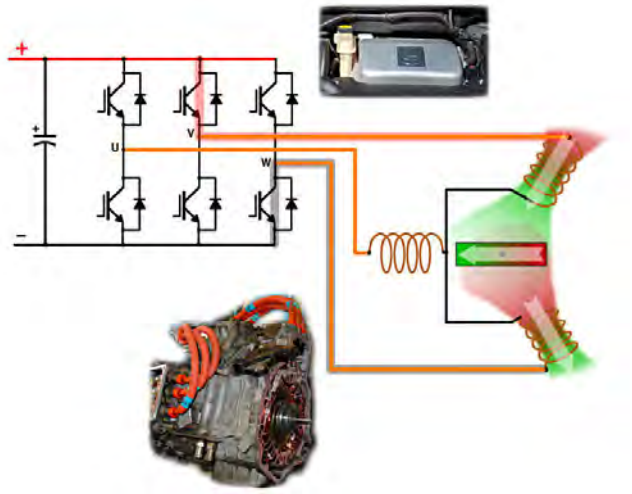
12

Major Hybrid Components



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Hybrid Common Electric Components

Review:

Simply put:

Inverters = HV DC to 3-phase AC & AC to DC on Regen

Converters = HV DC to 12V DC

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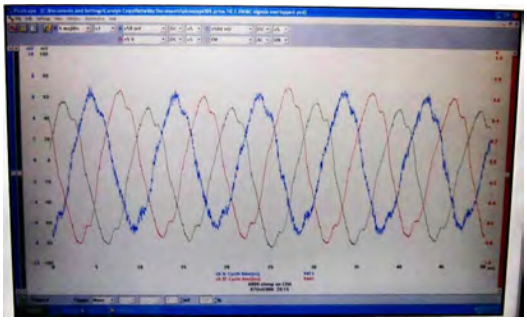
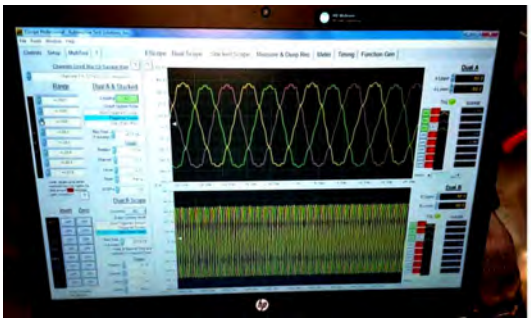
HV 3 Phase



3 amp clamps used to capture the signal on PICO



3 HV CAT III test leads to capture AC voltage on EScope

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15

15

Insulation Tests

Insulation tests should only be performed on dead circuits.

1. **Insert test probes in the + and – Insulation input terminals.**

2. Turn the knob to INSULATION position.

3. Press the Range button to select the voltage.

4. Connect the probes to the circuit to be measured.

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16

16

Insulation Tests

5. Push and hold the button to start the test.

6. Keep the probes on the test points and release the button.

Reading between 2.2 Gigohms and/or the OE spec is good.

Anything less than 2.2 Gigohms and the OE spec indicates an insulation problem.

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17

17

Insulation Tests

Diagnostic Strategy

Remember! The insulation tester is checking for voltage leaks in the cable insulation to ground:

1. If you test the circuit without disconnecting the cables, the tester should find the insulation problem, but you will not know where the fault is. Disconnect the cables one by one and testing them.

2. Do not disconnect the cable totally from the vehicle, leave the shielding ground connected to the vehicle.

3. Due to the internal connection of the motor (Star or Delta), all three phases are connected.

4. Look for areas of damage from an accident or from rodents.

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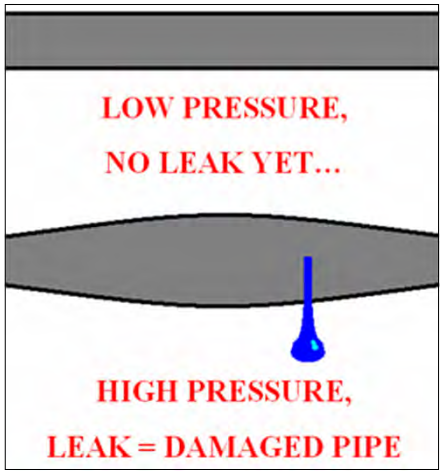
18

18

Insulation Tests

- **Basics:**
  - **Doing an insulation test is like pressure-testing a pipe.**
  - **You confirm a leak in a pipe by increasing pressure until liquid shoots out.**
  - **In wires, instead of liquid pressure, there's electrical pressure: VOLTAGE.**



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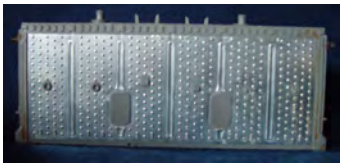
Cylindrical and Prismatic NiMH Batteries

Two types of NiMH cells are used in all of today's hybrid vehicle battery packs:

- **D size Cylindrical cells**

- **Rectangular Prismatic flat cells**



- **Capacity of both is ~ 6.5 AH**
- **Both can output more than 100 Amps**

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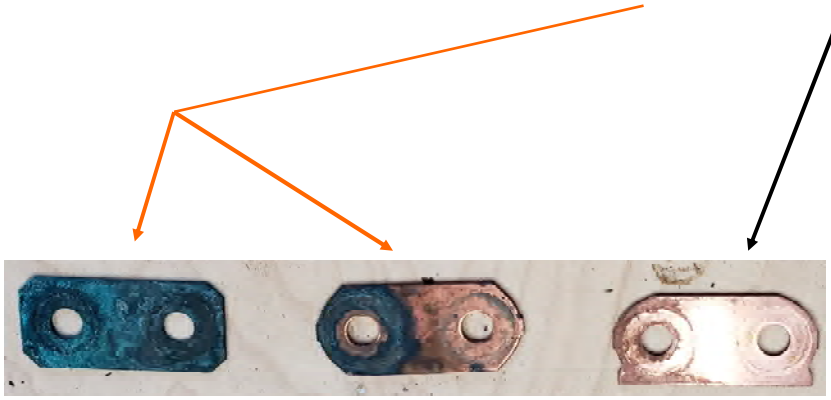
Prismatic Pack Bus Bar Voltage Drop – Dirty And Clean



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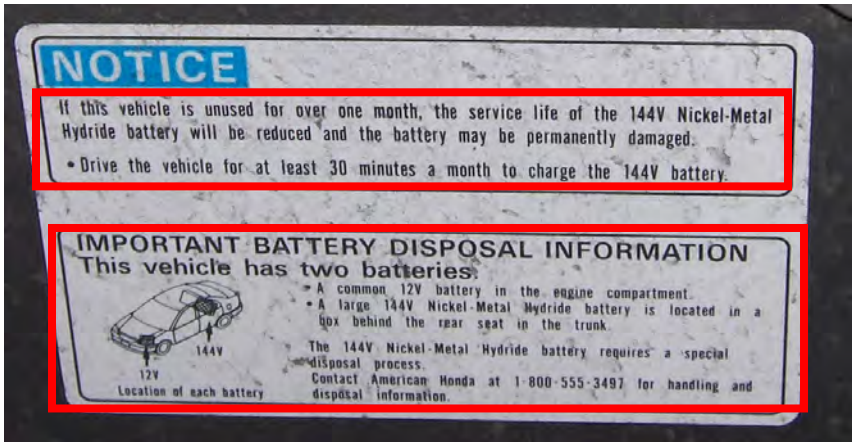
High Voltage Batteries

Notice: Don't let the vehicle sit for over a month



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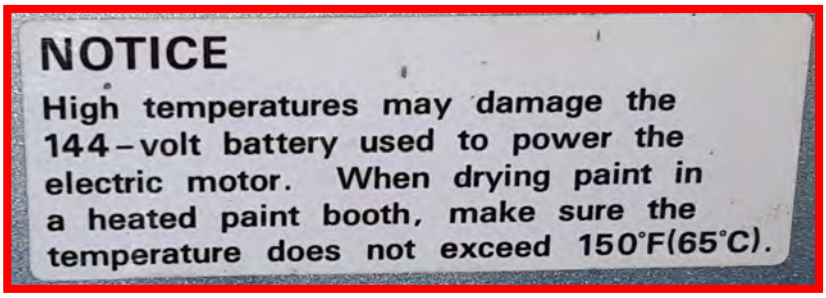
High Voltage Batteries

Notice: Don't: Don't Overheat The HV Battery



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Other Battery Cells

The Chevy Volt pouch cells are sandwiched together with coolant cells to ensure the pouches don't overheat. Each cell is around 5 x 7 inches (12.7mm x 17.7mm) and weighs around 1 pound	
The Volt modules come in different sizes and so are bolted together with different amounts of pouch cells, depending on the module. Coolant manifolds are shown at the bottom of the module on both sides	
The traction battery contains 5 modules with around 200 cells with an overall voltage of **around 360 V**	

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Other Battery Cells

Nissan Leaf The pouch cell is a self-contained battery. Maximum cell voltage is 4 V, but actual voltage is closer to 3.8 V.	
Each module contains 4 cells (2 in series and 2 in parallel). Series connection will increase voltage, parallel connection will increase capacity.	
The traction battery contains 48 modules with almost 200 pouch cells and an overall voltage of 360 V.	

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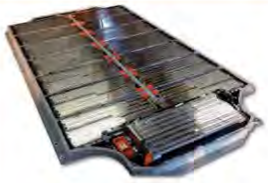
Other Battery Cells

Tesla uses the 18650 cell which has a rated voltage of 3.7v. The name comes from the battery's dimensions - 18mm x 65mm. (0.717 x 2.58 inches) (Update: Since 2017 Tesla now produce the 2170 battery - 21mm x 70mm.)	
Each module contains over 400 cells connected in both series and parallel. Also shown in the picture is the coolant connections.	
Depending on the size of the traction battery, it will contain 14 or more modules with an overall voltages between 300v and 360v.	

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Safety Interlocks

Interlock systems are installed to provide an extra safety point in powering down the high voltage. An example of a location of an Interlock connection would be under the Inverter cover.

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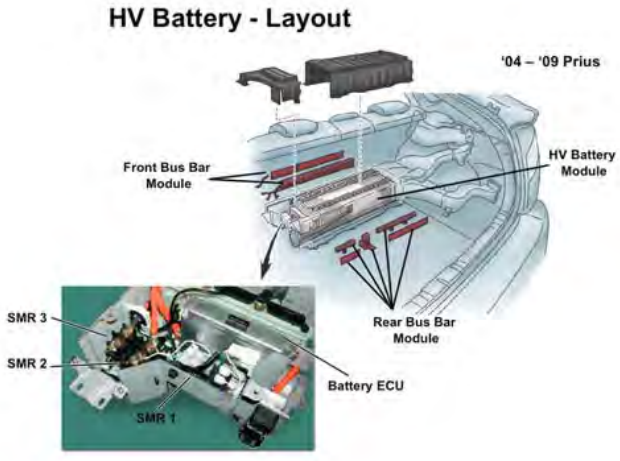
System Main Relays

SMRs connect and disconnect power to the high-voltage circuit based on commands from the HV ECU or PCM/ECU.

Three relays are used (one for the negative side and two for the positive side) operate in a programmed sequence to ensure proper operation and safety.



Source Toyota Motor Company

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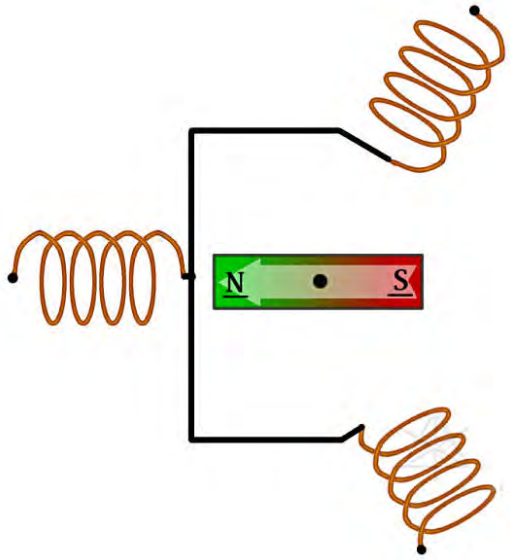
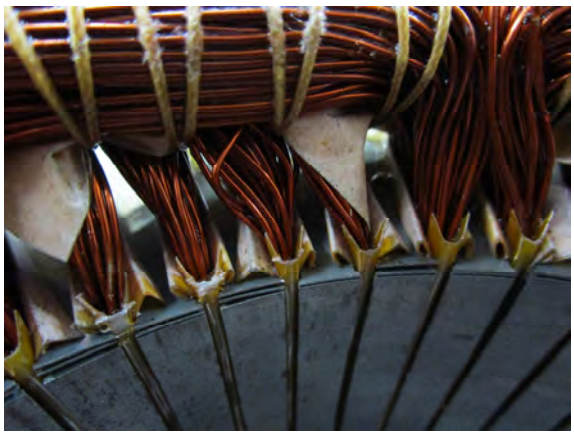
Motors 101





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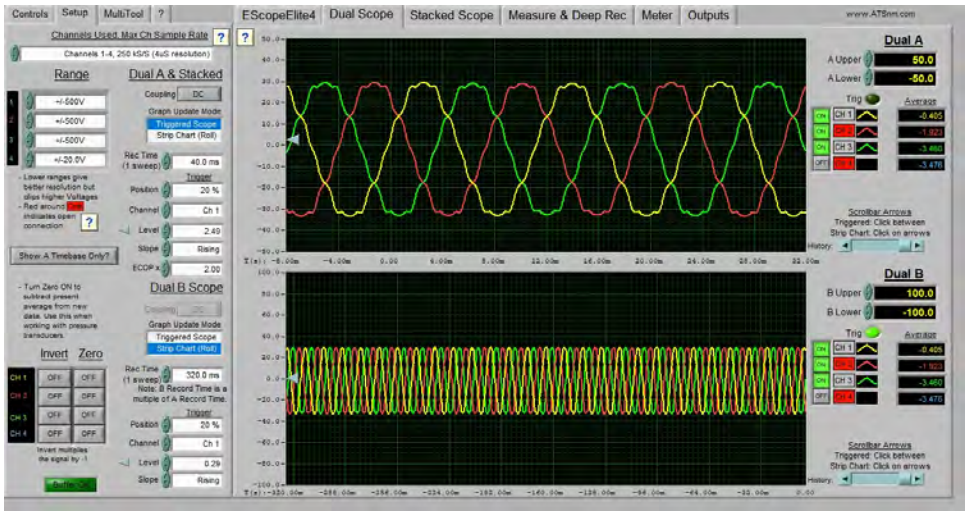
29

MG AC Voltage U V W



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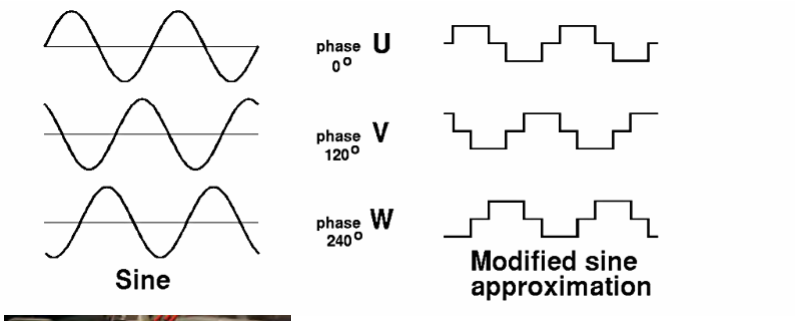
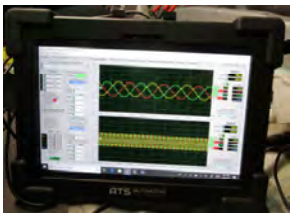
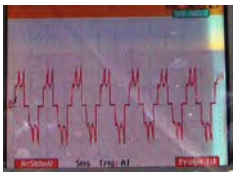
30

MG AC & DC Voltage U V W







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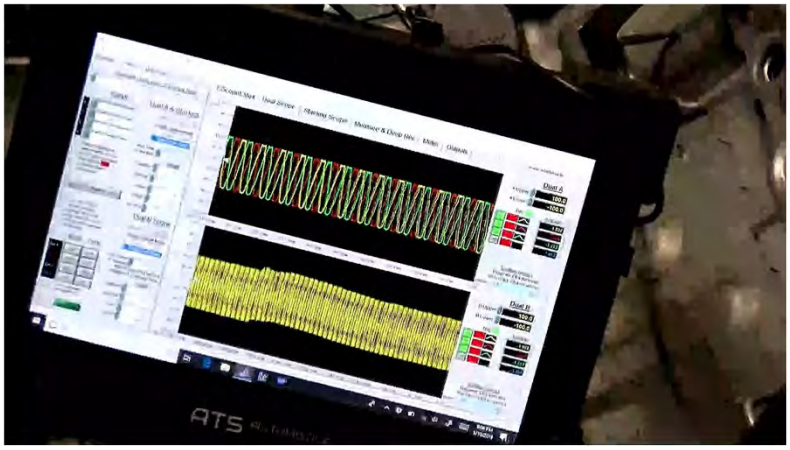
31

31

HV AC Voltage Of U V W After Rectification By The Inverter's IGBT's



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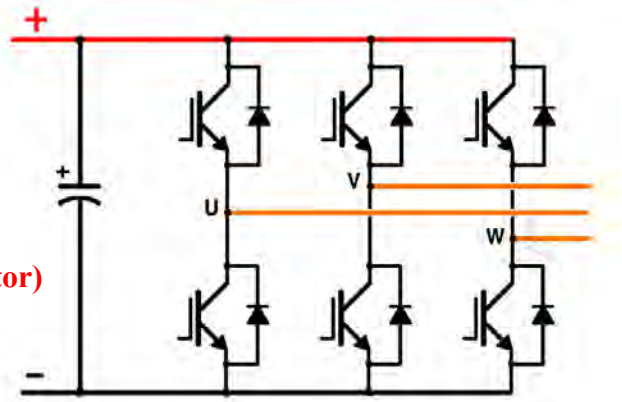
32

Inverters

- Turns 3-phase AC to DC & DC to AC
- Controller Turns On Transistor Bases
  IGBT (Insulated Gate Bipolar Transistor)



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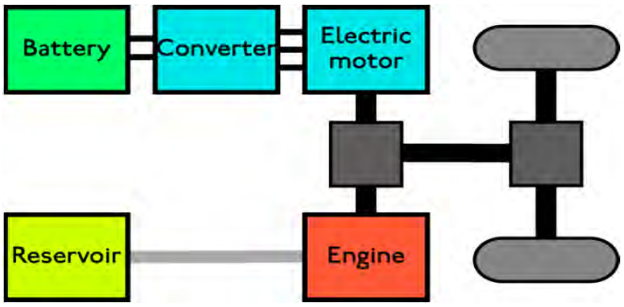
33

33

Parallel Design Hybrid



Parallel design: The parallel configuration uses a direct mechanical connection between the hybrids power unit and the wheels. An electrical motor is also used that can drive the wheel at the same time as the power unit. The ICE is typically used during normal highway driving.
Honda 1 MG along with the GM – Jeep – Ram - BMW etc…Alt/Gen Design

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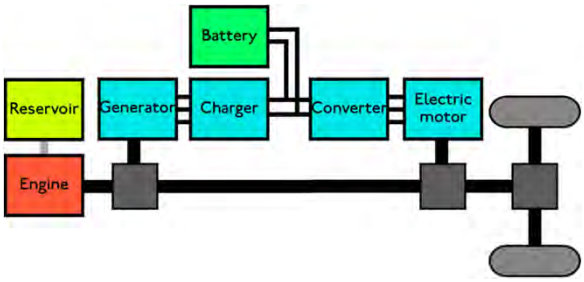
34

34

Series-Parallel Hybrid



Series-Parallel Hybrid: They incorporate power-split devices allowing for power paths from the engine to the wheels that can be either mechanical or electrical. The main principle behind this system is the decoupling of the power supplied by the engine, Atkinson cycle (lower power density, less low-rpm torque, higher fuel efficiency), (or other primary source) from the power demanded by the driver. Toyota-Ford-Nissan Others 2 MG Systems… *MOST USED

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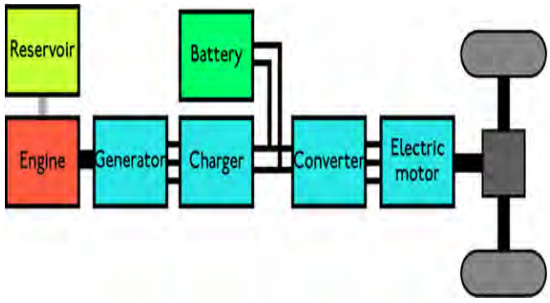
35

Series Design Hybrid



Series design: A power unit (ICE) turns a generator. This generator can either charge the batteries or power the electric motor to drive the transmission. This means there is NO mechanical connection between the hybrid's power unit and the wheels, thus the ICE never directly powers the vehicle. The Chevrolet Volt is an example of one such series extended-range electric hybrid.

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Honda Insight Battery

20 HV Battery sticks with 6 D size cells @ 1.2 volts per cell = 7.2 volts per stick

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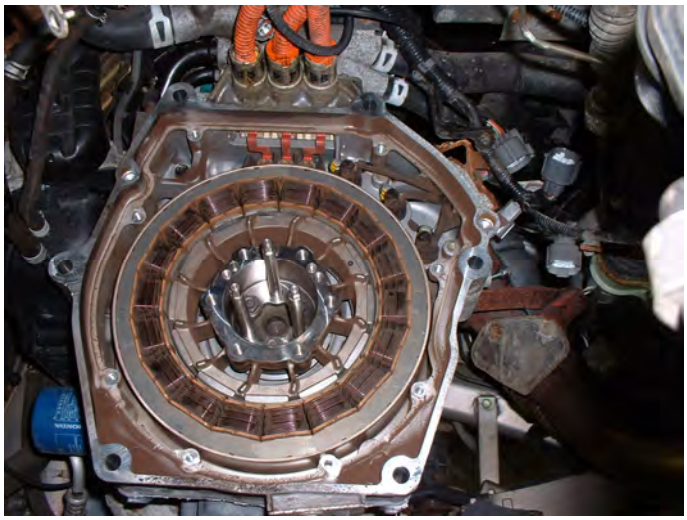
37

37

Honda Insight MG / IMA



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Honda Civic HV Cables And Motor

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Honda Civic HV Cables IMA End

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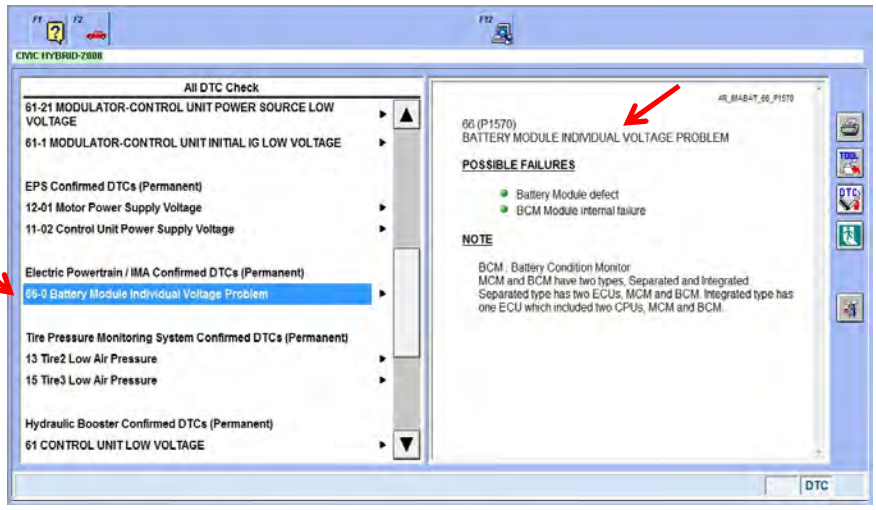
2008 Hybrid Honda Civic DTC 66-0 - P1570
Battery Module Problem



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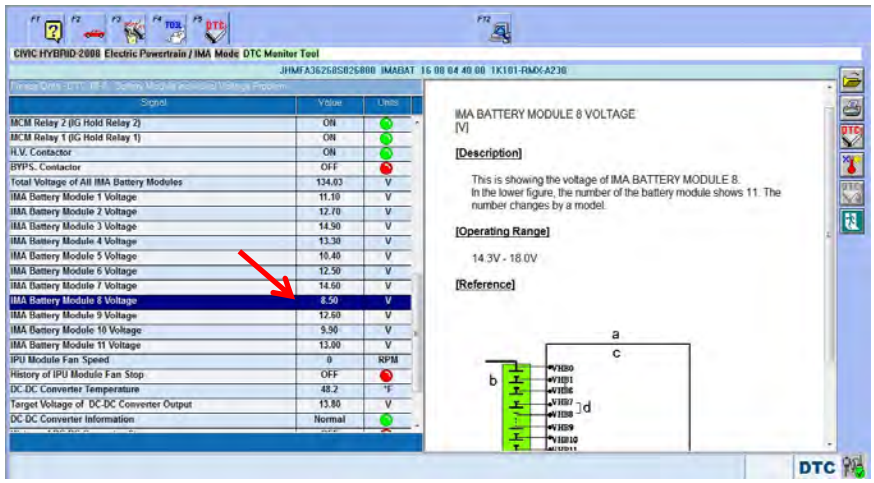
2008 Hybrid Honda Civic DTC 66-0 - P1570
Battery Module Problem



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42

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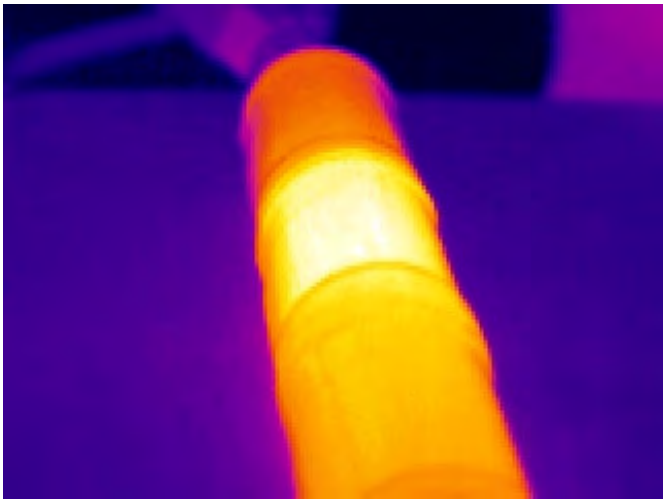
2008 Hybrid Honda Civic DTC 66-0 - P1570
Battery Module Problem



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Honda Accord Hybrid

2005 - 2006 Accord

This Compressor uses SE -10Y & POE oil and Special Dye for the System

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Prius MG 1

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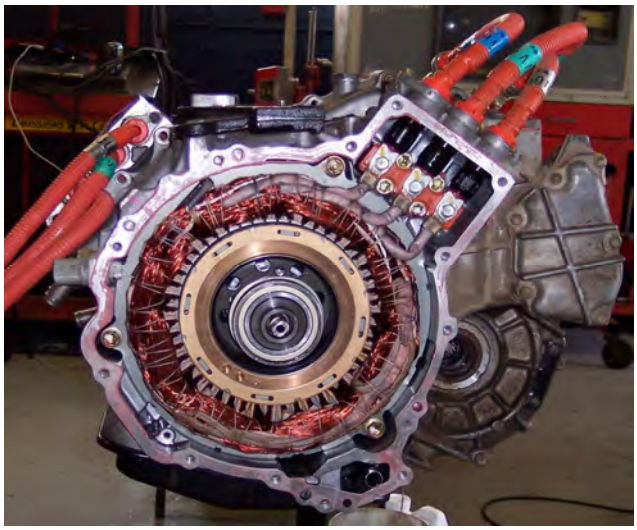
45

Prius MG 2



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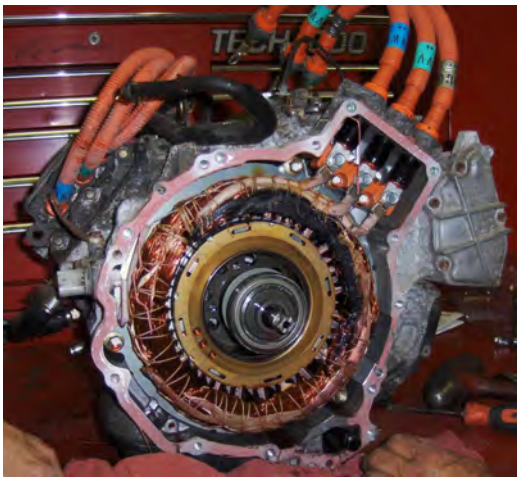
Prius Problems



The Problem Inverter and Motor Generator

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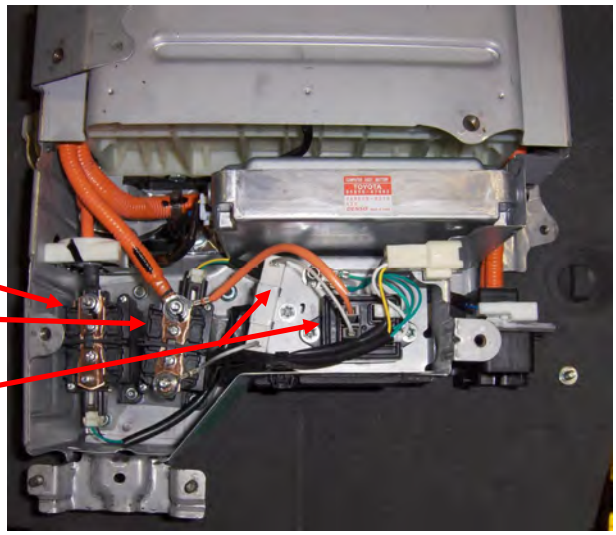
Prius Hybrid Info

- **SMRG is the Ground side**
- **SMRB is the Positive side**
- **SMRP is the Pre Charge Positive side**



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Toyota Prius Dash – Gen 2

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Toyota Prius Hybrid New Battery

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50

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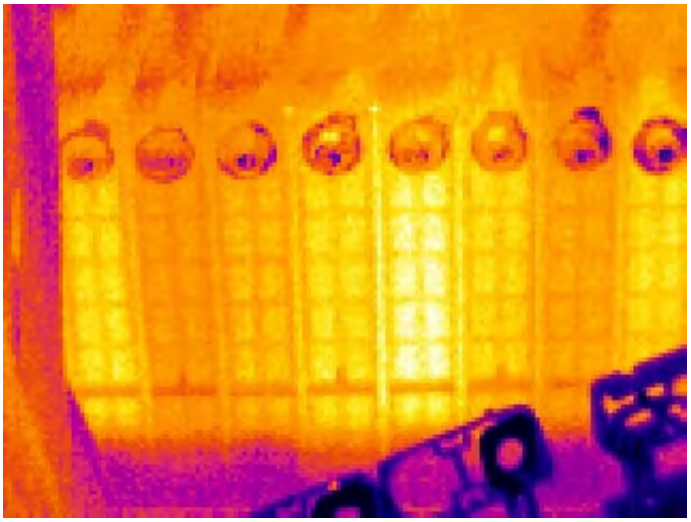
Toyota Battery Problem



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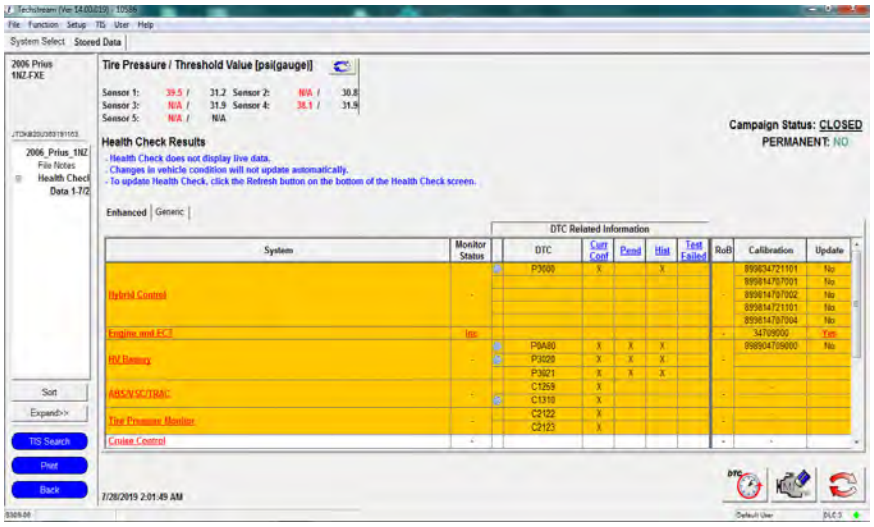
51

Toyota HV Battery Issue



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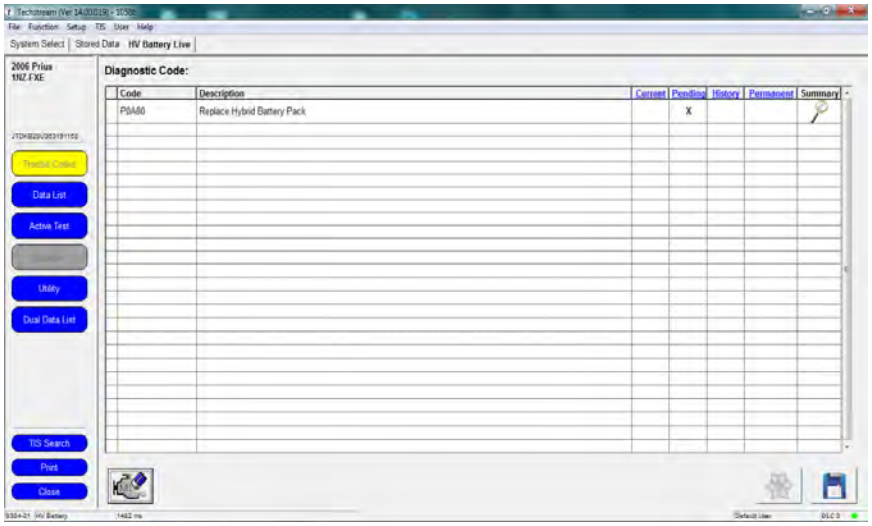
Toyota HV Battery Issue



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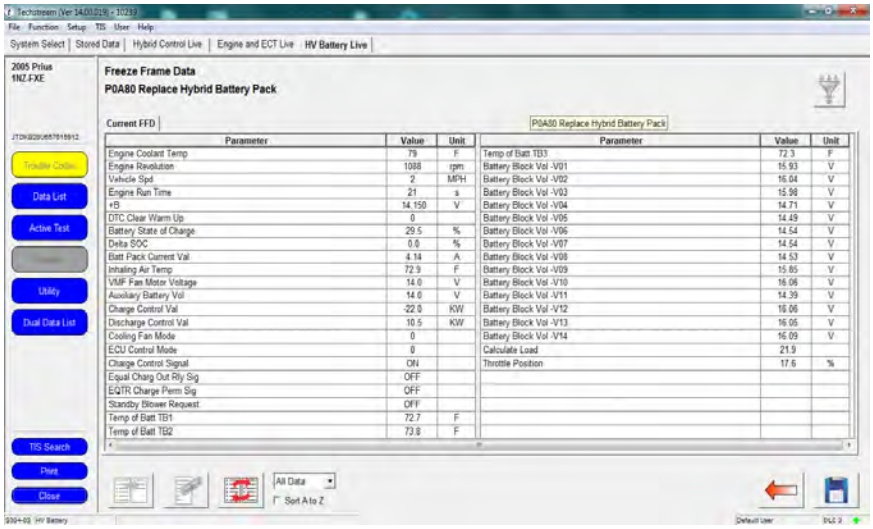
Toyota HV Battery Issue



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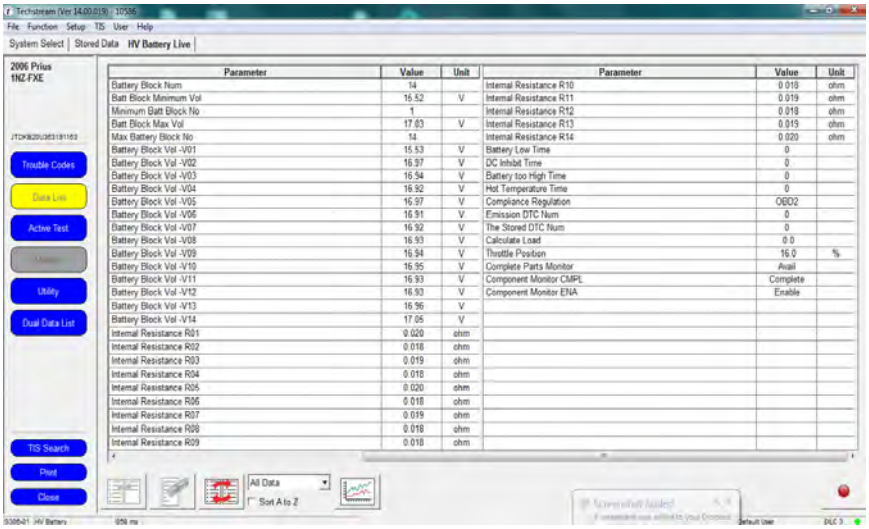
Toyota HV Battery Issue



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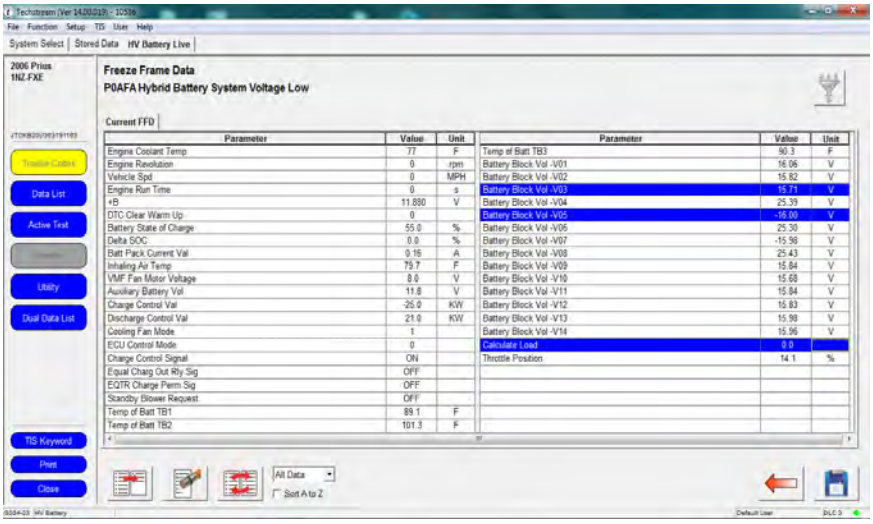
Toyota HV Battery Issue



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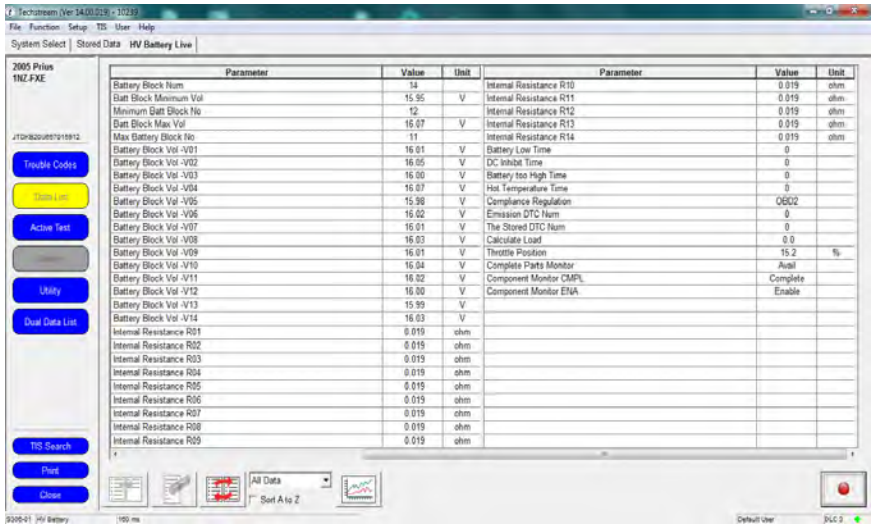
Toyota HV Good



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57

57

Testing A Toyota HV Battery Pack

Scan Tool PID Testing

Select the following PIDS for a faster update rate.

1. **Battery State of Charge (SOC)**
2. **Delta SOC**
3. **Battery Pack current**
4. **Battery Block Min**
5. **Battery Block Max**

Place the transmission in reverse and power brake the engine to draw the HV battery down as close as possible to 30%.

Look for the largest difference on Battery Block Min and Max Voltage - Delta.

Any more than 200 mV to 300 mV between Max and Min Readings = a problem.

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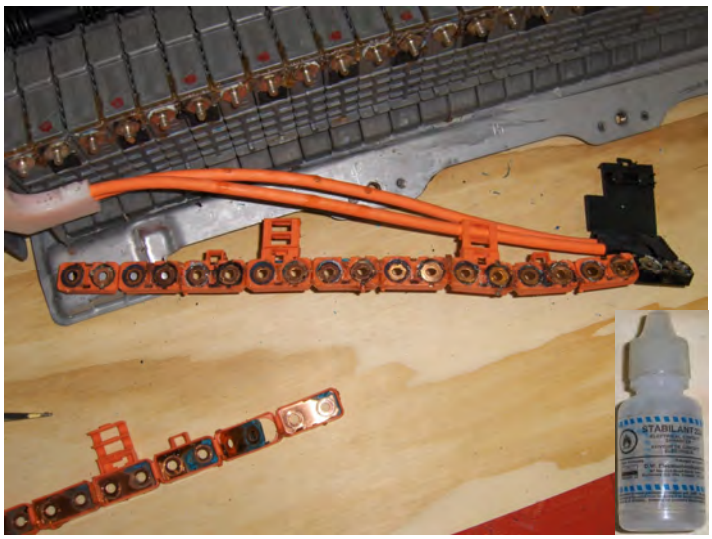
2001 Prius High Voltage Battery Problem



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2001 Prius High Voltage Battery Problem

Fix: Rebuilt High Voltage Battery

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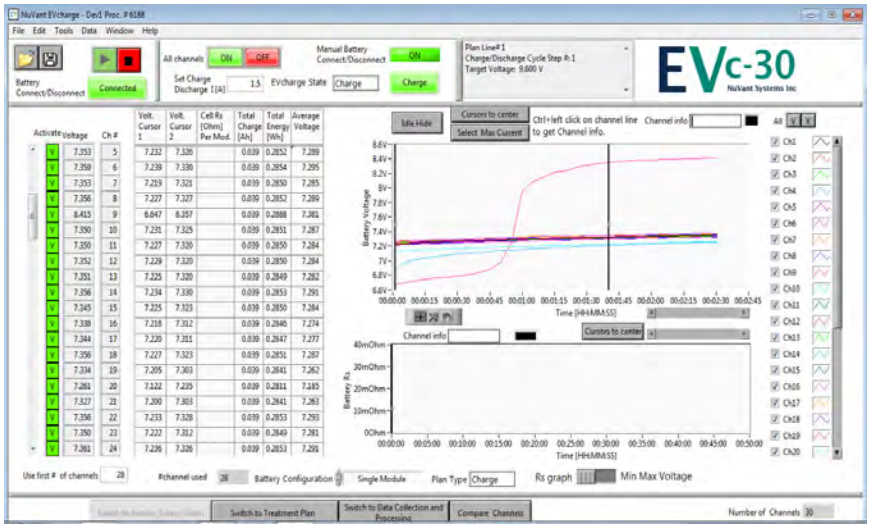
Toyota HV Battery Reconditioning Bad



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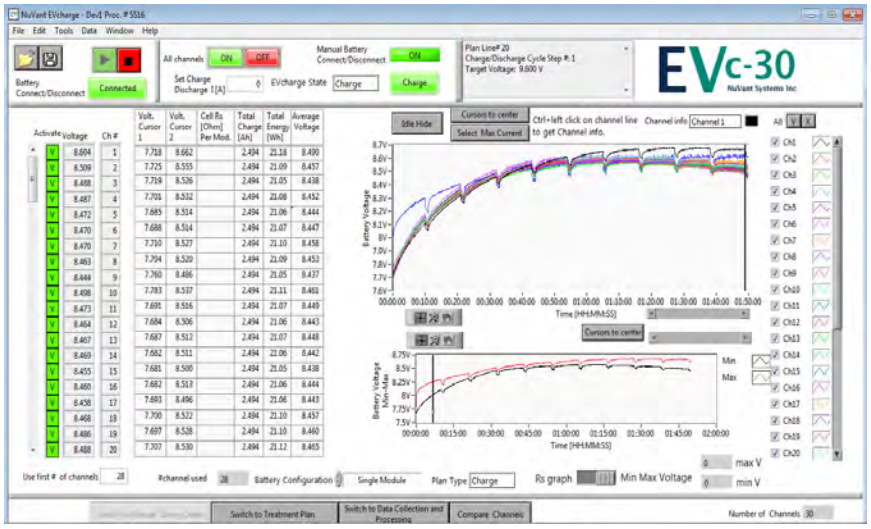
Toyota HV Battery Reconditioning Good



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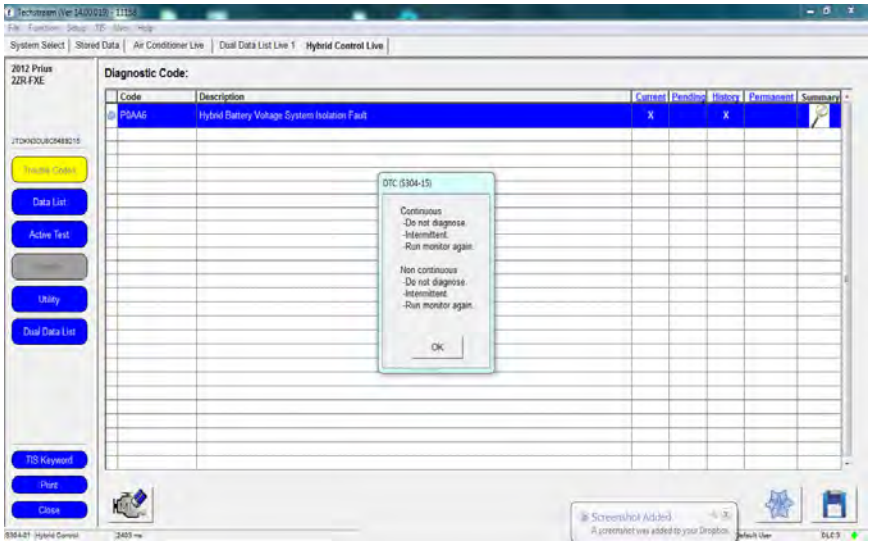
Toyota HV Isolation Fault



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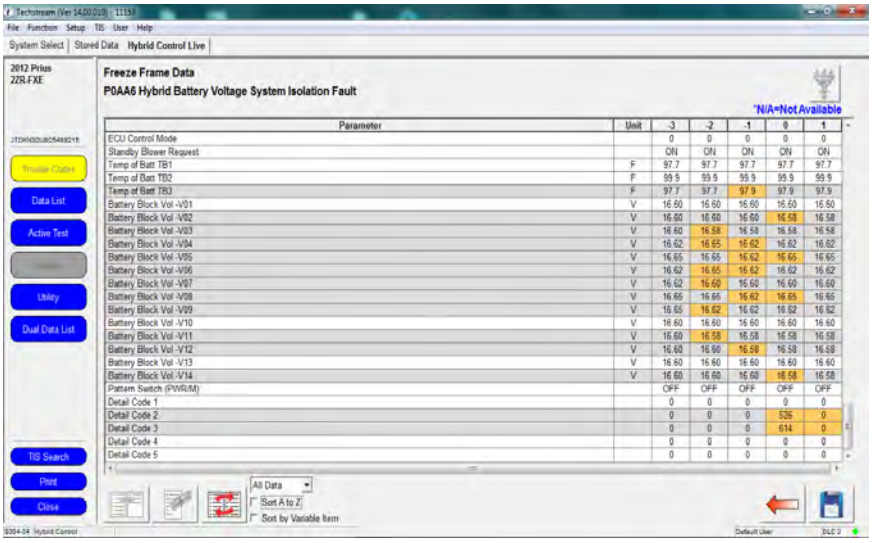
Toyota HV Battery Issue



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Toyota AC System

Is an electric brushless motor that is actuated by alternating current 201.6V that is supplied by the A/C inverter that is integrated into the inverter. The electric AC compressor consists of a spirally wound fixed scroll and variable scroll that is formed into a pair.

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Hybrid Ford / Mercury Electric Drive Motor 1

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Hybrid Ford / Mercury Electric Drive Motor 2

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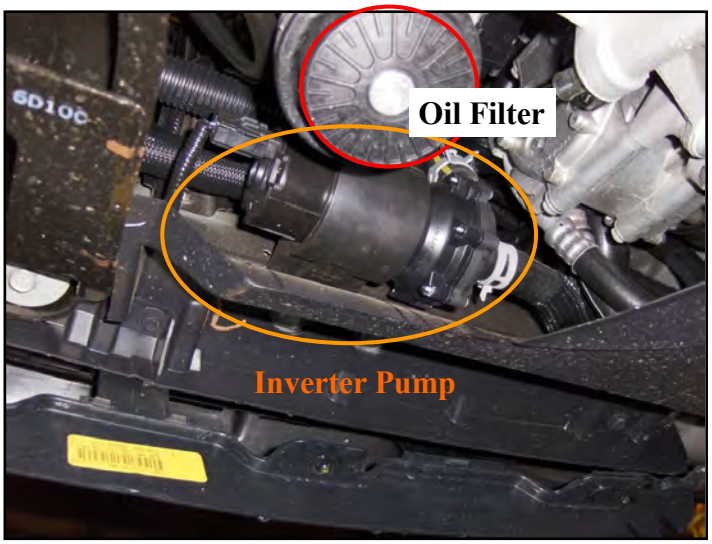
Hybrid Ford / Mercury Cooling Pumps



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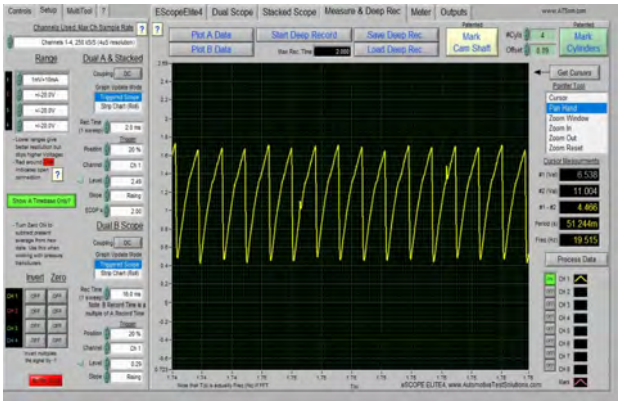
Hybrid Ford/Merc Current Ramping Inverter Pump



Almost looks like AC Voltage reading since it goes below and above zero.

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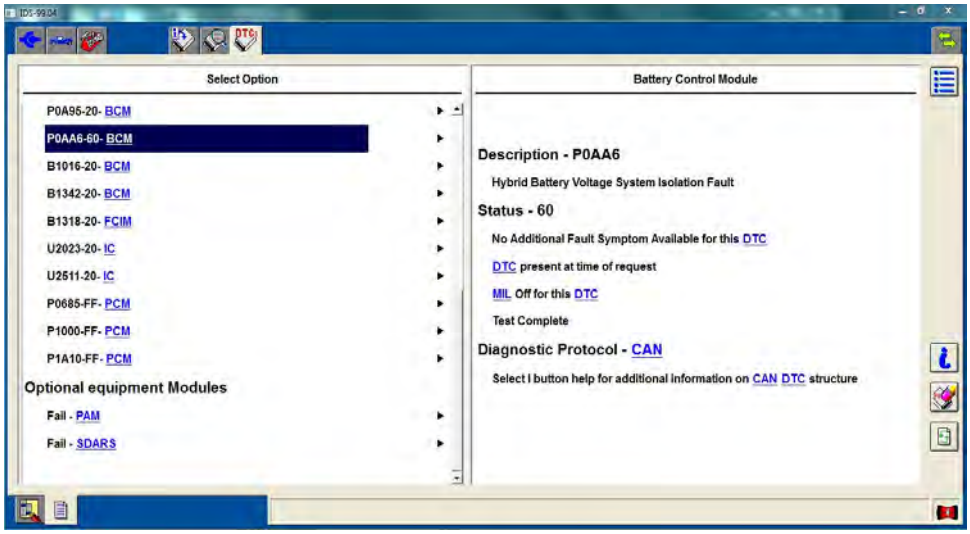
Ford / Mercury Hybrid Shut Down



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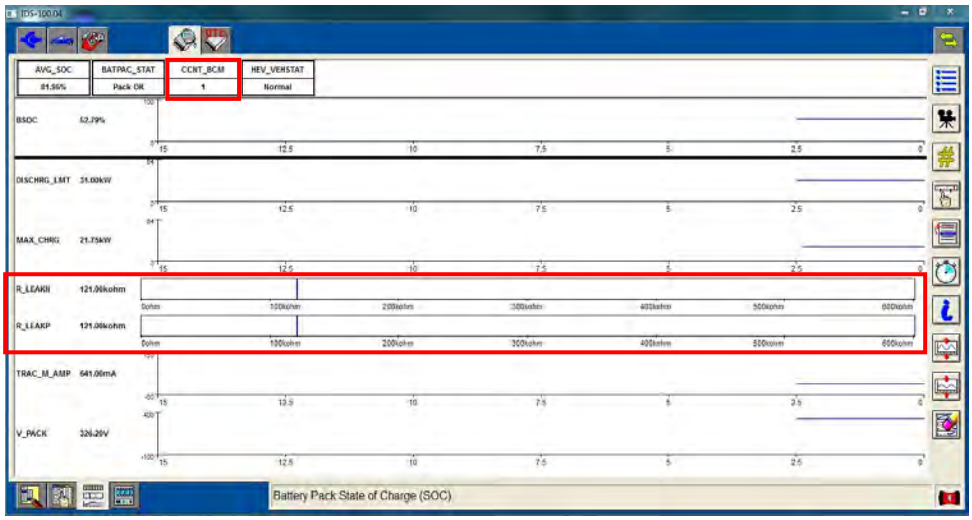
Ford / Mercury Hybrid Shut Down



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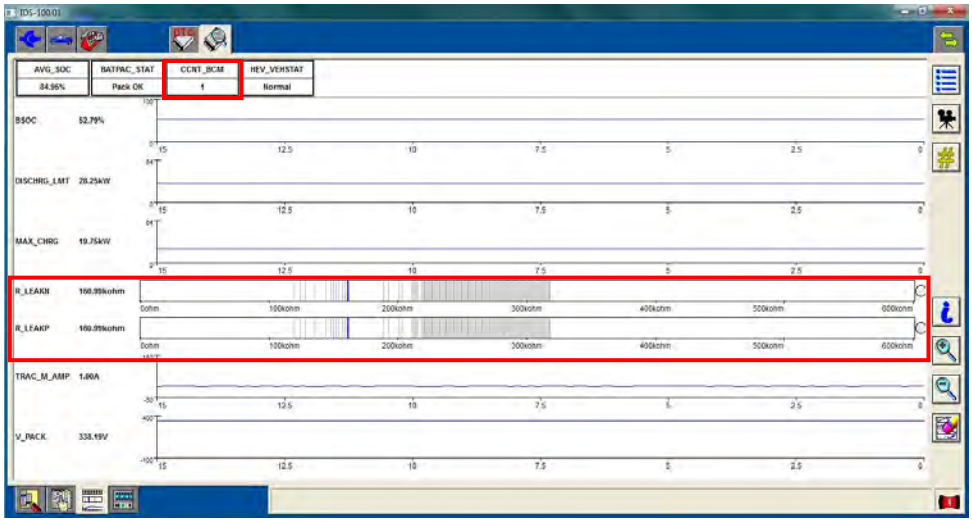
Ford / Mercury Hybrid Shut Down



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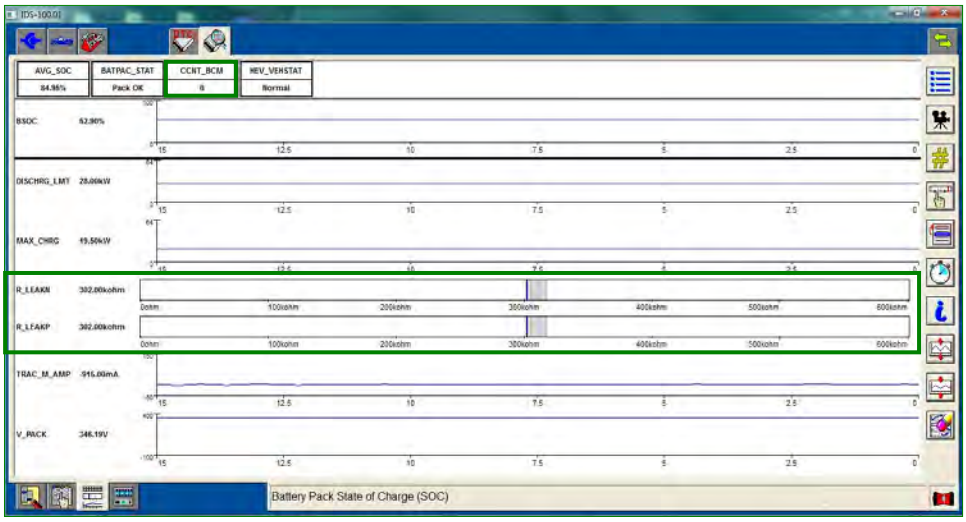
Ford / Mercury Hybrid Shut Down



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GM Chevy VOLT - EREV (Extended-Range Electric Vehicle)

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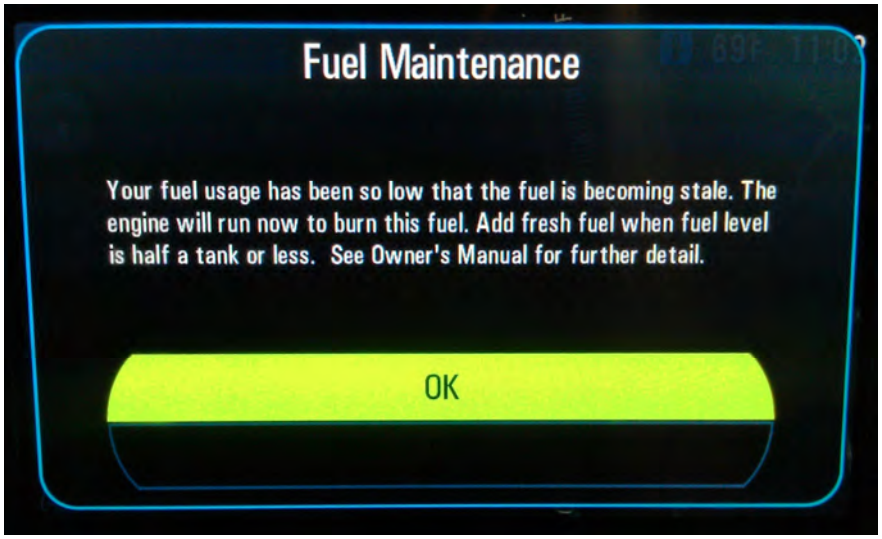
GM Chevy VOLT



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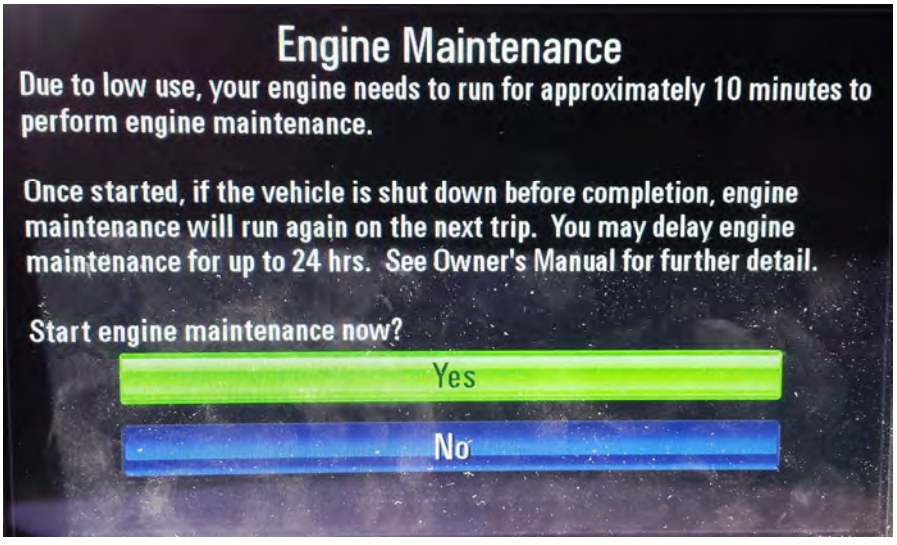
GM Chevy VOLT



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Chevy Bolt

3 EASY WAYS TO CHARGE

1. **The standard 120-volt charge cord allows you to charge your vehicle wherever there's an outlet.**

2. **A 240-volt/32-amp charging station offers 25 miles per hour of charge time†.**

3. **Available DC Fast Charging allows you to get about 100 miles in around 30 minutes of charge time†.**

4. **259 miles of pure electric range on a full charge**

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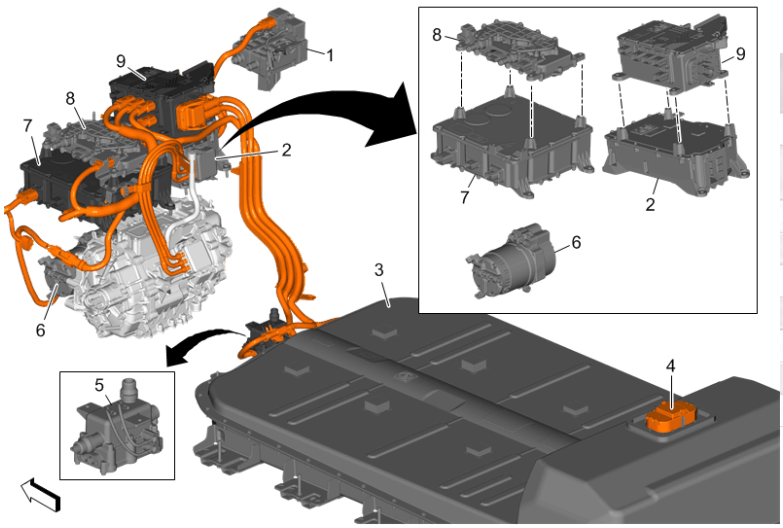
Chevy Bolt



Callout	Schematic Reference or Generic Name
1	K10 Coolant Heater Control Module
2	T6 Power Inverter Module
3	A4 Hybrid/EV Battery Pack
4	S15 Manual Service Disconnect
5	E54 Hybrid/EV Battery Pack Coolant Heater
6	G1 A/C Compressor
7	T18 Battery Charger
8	K1 14V Power Module
9	T24 Battery Charger - DC

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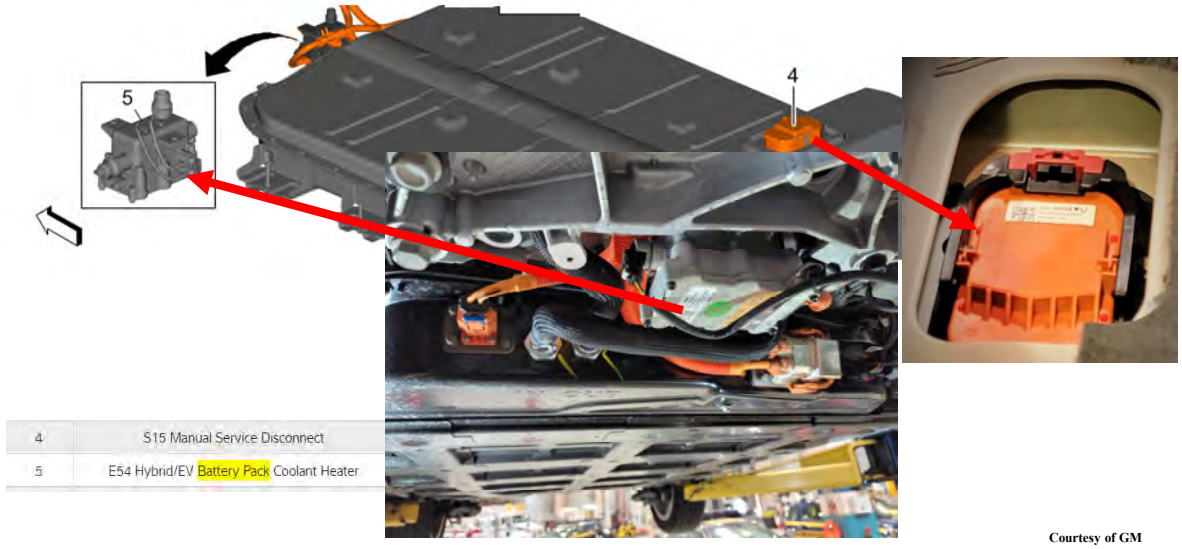
Chevy Bolt



4	S15 Manual Service Disconnect
5	E54 Hybrid/EV Battery Pack Coolant Heater

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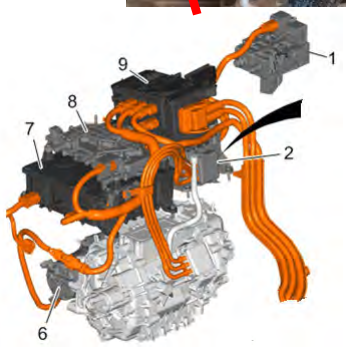
1	K10 Coolant Heater Control Module
6	G1 A/C Compressor
8	K1 14V Power Module
9	T24 Battery Charger - DC
7	T18 Battery Charger



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Callout	Schematic Reference or Generic Name
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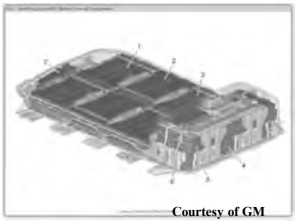
The high voltage hybrid/EV battery contains 288 individual lithium-ion cells. Three cells are welded together in parallel and called a cell group. There are a total of 96 cell groups in the hybrid/EV battery assembly. These cell groups are electrically connected in series. Each individual cell group is rated at 3.65 V, for a nominal system voltage of 350 V direct current. The battery cell groups are electrically joined to form 10 distinct electrical modules. There are eight electrical modules comprised of 10 cell groups and two electrical modules comprised of 8 cell groups. Two battery cell modules are physically mounted together to form a section/row. Section/row 1 and 3 are interchangeable while section/row 2, 4 and 5 are unique to their location. With the exception of section/row 5, the two battery cell modules are not electrically connected within their respective section/row.



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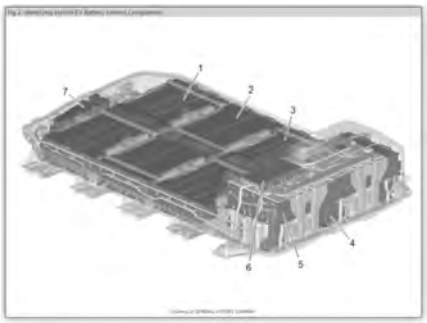

Hybrid/EV Battery Internal Components

Callout	Schematic Reference or Generic Name	Scan Tool Reference	Service Information Part Name
1	C4A Hybrid/EV Battery Section 1	Not Applicable	Cell Battery Module (Row 1, 3)
2	C4B Hybrid/EV Battery Section 2	Not Applicable	Cell Battery Module (Row 2)
3	C4C Hybrid/EV Battery Section 3	Not Applicable	Cell Battery Module (Row 1, 3)
4	C4D Hybrid/EV Battery Section 4	Not Applicable	Cell Battery Module (Row 4)
5	C4E Hybrid/EV Battery Section 5	Not Applicable	Cell Battery Module (Row 5)
6	K16 Battery Energy Control Module	Battery Energy Control Module	Battery Energy Control Module
7	A28 Hybrid/EV Battery Contactor Assembly	Not Applicable	High Voltage Battery Disconnect Relay

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Diagnostic Aids

The Hybrid/EV Battery Pack Capacity Learn procedure must be completed when the following components are replaced:

- **Hybrid Powertrain Control Module 2**
- **Hybrid/EV Battery Pack**
- **All battery sections**

Whenever the Hybrid/EV Battery Pack Capacity Learn is activated the vehicle needs to be operated in a normal manner in order to learn an accurate battery capacity value.

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NEVER disconnect the 12V battery supply to the vehicle or the hybrid powertrain control module 2 after initially activating the Hybrid/EV Battery Pack Capacity Learn. Loss of 12V power will force the hybrid powertrain control module 2 to store the current capacity value as accurate and will also disable scan tool learning. The process needs to complete without 12V battery interruption for the best results.

Repeat the Hybrid/EV Battery Pack Capacity Learn any time 12V battery interruption occurs prior to operating the vehicle by driving and/or charging. It is possible to observe whether an update has occurred by looking at the battery capacity after charging and/or driving the vehicle.

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The scan tool learning process will complete when three capacity updates are recorded. The initial capacity update during the scan tool learn process will have the greatest effect. Capacity updates can only occur during certain driving parameters so it may take many more than 3 drive trips for the process to complete. Factors that the process is dependent on include the drive trip style, where highway driving is preferred, and battery temperature, among others.

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Tesla Has The Same Components Without The ICE
Just Package A Bit Different

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EV & Hybrid Charging Station

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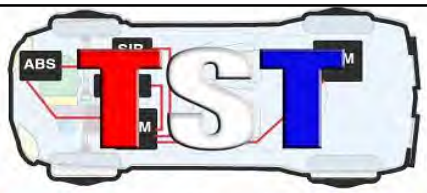

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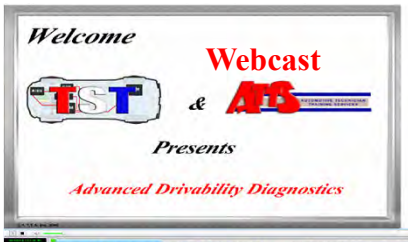

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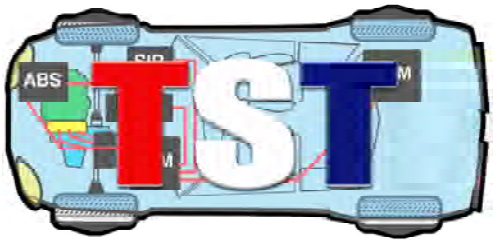

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92